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SIXTH ANNUAL REPORT

ON THE

GEOLOGICAL SURVEY

OF

PENNSYLVANIA.

—
BY HENRY D. ROGERS,
STATE GEOLOGIST.
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HARRISBURG:
HENLOCK & BRATTON, PRINTERS.
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Read in Senate, February 9, 1842.

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REPORT.

To the Secretary of the Commonwealth:

SIR:—I beg leave, in compliance with the law, to transmit to the Legislature the following Report of the progress of the Geological Survey of the State, during the past year.

In my former annual communications, I submitted some detached portions of the geological and chemical results of the Survey, which were, occasionally, minute. These annual sketches seemed called for by the public wish, and were appropriate enough, so long as a considerable time yet remained to the completion of the work. But now, that the survey is nearly finished, the inducement to make a partial publication of details has ceased, and the large accumulation of materials, renders it imperative upon me to give the whole of my time to the laborious task of preparing my final report. The unavoidable omission, for the present, of minute descriptions, is the less to be regretted since we are under the necessity of postponing the publication of the maps and other drawings so essential to the proper illustration of whatever is local, until the appearance of the final report. To bring forward now, the partially finished fragments of the work, when another year will, probably, suffice to mature the whole and accompany it by all the requisite illustrative drawings, would be to incur a needless present expense and an ultimate delay. The interests of the survey will, therefore, be best consulted if I confine myself, on this occasion, to a brief notice of our investigations for the past year, and to a general account of the present posture of the work, with some suggestions for bringing its results speedily and in the most useful form before the public.

The general description of our geology, which will form my concluding labour, and which alone can convey a just idea of the economical importance and scientific value of the survey, I shall zealously

endeavor to complete in time to present to the Legislature at its next session. Meanwhile, the sketch I am about to offer, of the plan and scope of my final report, will enable the Legislature to perceive the necessity of granting me the time I ask, and of devising the best method of bringing my results, with the least delay, before the public.

Operations of the Geological Corps during the past year.

The unfinished explorations of previous seasons were resumed in May last, as soon as the Legislature authorized the prosecution and completion of the survey. The delay of a few weeks in taking the field, while waiting for legislative action, proved a somewhat serious inconvenience, as it compelled me to procure additional aid with the fund provided for incidental expenses, and forced some of my corps to continue the campaign until the close of November, when the coming on of actual winter put a bar to all further researches.

Assigning to my assistants, under the present reduced organization of the corps, the examination of those districts respectively with which they had already become partially familiar, Mr. Alexander M. Kinley undertook the completion of his researches in the coal fields of Broad Top mountain and the Wyoming valley, while Mr. Harvey B. Holl, Dr. R. M. S. Jackson, Mr. Peter Lesley, and Mr. Martin H. Boye, resumed the exploration of the great bituminous coal region, north-west of the Allegheny mountain. In the month of August, Mr. Lesley transferred his attention to parts of the anthracite district, where he spent the remainder of the season collecting materials for perfecting the geological map of that intricate region. A little later, Mr. Holl, after accomplishing his duties in the west, entered upon some special researches in the country bordering the Juniata river, from its source to the Susquehanna. Throughout the year, Dr. Robert E. Rogers, my chemical assistant, was engaged in the labors of the laboratory.

In the rather intricate and obscure coal field of the Broad Top mountain, in Bedford and Huntingdon, several weeks were passed in an earnest endeavor to unfold its structure and trace the coal. Several persons were employed at intervals in digging and mining, with a view to identify the various coal seams, at the localities which promised the best results. Though during this and previous season's researches we had gained a tolerable insight into the obscure stratification of this district, we are now convinced, that to unravel entirely all its local complexities would require an amount of time and an organized system of mining, not compatible with the resources, nor

indeed with the plan of the survey. Enough of its detailed geology will, I trust, be made known, through my final report, to accomplish one main practical object, that of aiding, materially, the future explorations of persons interested in the soil, so as to prevent much useless waste of capital.

The long and well defined valley of the Wyoming and Lackawanna coal basin, extending from Carbondale to Beachgrove, was in certain districts minutely examined during the latter part of the summer and autumn, our limited time and means alone preventing the thorough exploration of a few unfinished neighborhoods. From its western termination, as far eastward as the mouth of the Lackawanna, the valley was studied with very considerable minuteness. The comparatively more simple geology of the portion occupied by the Lackawanna had been examined with some care, in a former season, when we collected a series of transverse sections of the strata, with a view to explain its interesting local features and resources.

The Wyoming valley, as distinguished from the Lackawanna division of the basin, discloses a structure of very perplexing intricacy. Its thick mass of coal measures, far from lying in the form of a simple trough, contains a series of anticlinal axes, and a succession of short and abrupt foldings of the strata, which give to many parts of it a very disturbed character. From Nanticoke to the western extremity of the basin, this structure is more especially predominant. Though it causes considerable difficulty in identifying and tracing particular beds of coal, we succeeded in establishing some important general facts respecting the direction of the lines of disturbance, a knowledge of which will render the future discovery of any particular seams of coal, or other strata, comparatively certain. One leading and important general determination relates to the curious parallelism of the anticlinal axes with the southern boundary of the valley, locally called the Little mountain. These lines of elevation are consequently oblique to the Nanticoke or River mountain on the north.

A complete vertical section of all the coal measures in this basin, from the underlying conglomerate rock to the highest coal seam, is still a desideratum. Want of time, rather than the complexity of the stratification, to which we now possess a sufficient clue, prevented our entire success in collecting the requisite materials. Enough has, however, been established by a comparison and union of the numerous local sections examined, to make known the existence of a greater number of coal seams in the basin than had previously been suspected to exist. A tolerably full section was measured along the

railroad of the Wyoming Coal Company, where we ascertained the relative distances and thicknesses of nine seams of coal. The thickest coal-bed of the basin lies to the south of any seam yet intersected in the cuttings of this railroad. Beneath it, but still above the conglomerate, there are at least three other beds of a size fit to work. Higher in the series than that which is styled the "Slope Vein," we have ascertained several others to exist, some of which will probably prove important.

The lowest coal seam in the basin, reposing at Nanticoke, nearly on the conglomerate rock, was identified at many localities, and carefully traced westward to Beach's mine at the river. It is mined by Col. Lee, at Nanticoke, and has been opened by Mr. H. Colt in the "Hogback," and at the foot of the River mountain. It is also wrought by Mr. Harvey, who has, besides, opened it near the top of the mountain. At Plymouth, the mines of Thomas, of Reynolds, and of F. Smith, are established in this coal-bed. North-eastward of Plymouth it seems to decrease in thickness. The lowest of the two beds, opened in the "Hollow" by Mr. Raub, we are disposed to regard as also identical with this seam.

The thickest mass of coal in the whole basin is the great bed of the Baltimore Company's mine, which, in some places, measures thirty-two feet, embracing, of course, several thin bands of included slate. This is not the same seam as that wrought by Lee and Harvey, its position being considerably higher in the series. The bed seems to have its greatest thickness at the large mine of the Baltimore Company, and to decline in size as it extends to the south-west. Many openings have been made into this bed in the Little mountain. It is supposed to be this seam which is wrought by Hurbut and by Stivers. That wrought by Mr. Holland in Neseopeck township, is certainly the same.

The wide bituminous coal region, north-west of the Allegheny mountain, claimed the attention of the other members of my corps, and a large share of my own, for the greater part of the season. In exploring the unfinished portions of this district, we succeeded, combining and applying the results of previous seasons, in unfolding its grand yet simple features of stratification, to an extent far surpassing my most sanguine anticipations. To Mr. Lesley was assigned the duty of examining the numerous detached small coal fields, scattered over the northern counties of the State, from the North Branch of the Susquehanna to Jefferson county. By giving strict attention to the range and distribution of the strata beneath the coal, and to the manner in which they rise to the surface along a series of parallel

anticlinal belts, the various insulated patches of the coal formation were successfully traced, and found to be distributed with an unexpected degree of symmetry, in a succession of singularly regular troughs or basins. Besides determining, with tolerable accuracy, the area occupied by each local tract of coal measures, we were enabled, in most instances, to identify particular seams of coal and beds of iron ore, and so to establish their characters and position as to make it easy hereafter for individuals to trace them. When we consider the yet wilderness condition of a large portion of this district, and the consequent fewness of good exposures of the rocks, we can ascribe our success, such as it has been, only to the remarkable persistency of the strata. To describe the geology of these northern counties, either intelligibly or with profitable minuteness, would require a constant reference to our yet unfinished map and sections. I shall, therefore, postpone all details, until I can present them in their proper connection in my final report.

To Mr. Holl and Mr. Boye was entrusted the duty of carefully unfolding the stratification of the large and productive coal region lying to the west and south-west of the eastern line of Jefferson county, as far as the Ohio line on the one side, and the valley of the Kiskiminetas on the other. Guided by the knowledge of the strata previously obtained, Mr. Holl applied himself to tracing out in detail the various coal seams, limestones, beds of iron ore, and the other deposits of that large tract of the coal measures which ranges from the western part of McKean county, through Venango, Clarion, Mercer, Butler, Beaver, and part of Armstrong. This district constitutes a regular and natural basin, widening and deepening towards the south-west. It is the sixth and last trough of our western coal formation, counting north-westward from the Allegheny mountain. On the N. W. it is definitely limited by a belt of country, composed of the great coal conglomerate which ranges to the south-west out of Warren, through Venango, into Mercer. On the S. E. it is bounded by a well marked anticlinal axis, passing from near Smethport in an almost straight line towards Pittsburg.

The detailed examinations made in this basin during the past year have now rendered it certain, that the limestones and many of the coal seams are continuous over very extensive areas, though the individual beds frequently change much their thickness and external aspect. The included sandstones, slates, and other more mechanically formed rocks, display, however, incessant variations of thickness and composition, which make it impossible to trace these individually,

over any very wide extent of country. Thus, two seams of coal, in some places separated by sixty feet of strata, will at other points lie within twenty feet of each other.

Viewing the whole of the 700 or 800 feet of coal measures, which occupy this trough north of the Ohio river, we find eight widely distributed coal seams, besides several smaller local ones. Those which are important for their dimensions, I shall designate for the sake of present convenience, by their position, counting from the lowest upwards. The four lowest beds, which are included between the first and second thick sandstones, and which are developed, chiefly, in Mercer, Venango and Warren, are neither as continuous nor for the most part as thick, as the beds above them. One which occurs at the town of Mercer and at Sandy Lake, possesses, however, a thickness of from four to six feet. Accompanying these lower coals in Mercer county, we find the lowest bed of limestone any where met with in our western coal measures. Of the *fifth*, *sixth*, *seventh*, and *eighth* coal seams, which are much the most continuous and uniformly valuable, the *fifth* is the main bed, seen at Fallston, New Castle, Kittanning, Murvinsville, and in Irwin and Scrubgrass townships, in Venango. The *seventh* is the most important bed on the Allegheny river about Sugar creek and on the Red bank; while the *eighth* is the chief seam at the town of Butler. This last, which is a very valuable bed, accompanies the preceding, though at a greater elevation in the hills, in the vicinity of Sugar creek and Kittanning, and in the neighbourhood of Freeport. These several coal-seams, together with the limestones, have been regularly traced by their outcrops, and their positions recorded on the map, while the various circumstances of their thickness, change of distance and accompanying strata, have been carefully recorded.

A portion of the season was devoted by Mr. Holl to similar researches, in parts of the three parallel basins, situated next to the eastward of the large one just spoken of. The beds of coal and limestone of these troughs, have now for the most part been identified with those in the westernmost basin, though their accidents of thickness and quality are often different. Thus the *fifth* coal-seam, where it occurs about twelve miles east of Brookville, measures between eight and nine feet. The *seventh* bed occurs in considerable size at Punxatawny, and it is ten feet thick between the Red bank and Mahoning, on the road from Kittanning to Brookville. The *eighth* is the most available seam in the neighborhoods of Curwensville and Mount Pleasant. Throughout all this wide range of country, this last coal-bed

is accompanied by an underlying limestone, the position of which is well seen around Freeport.

To Mr. Boye I confided the task of examining, in detail, those districts of Armstrong and Indiana, which lie between the Kiskiminetas or Conemaugh on the south, the Big Mahoning on the north, the Allegheny river on the west, and the range of the Chesnut ridge on the east. The valleys of the Conemaugh and Kiskiminetas cutting deep into the strata, afforded an excellent opportunity for determining the position of several of the parallel troughs into which the coal measures of this region are distributed, and for instituting accurate measurements at various points, with a view to the identification and tracing of the special beds of coal, limestone, iron ore and other useful strata. By using the data thus furnished, the difficulties which had hitherto retarded the working out of the geology of this district, caused mainly by the variability of the slates and sandstones, was successfully overcome, and a sufficiently minute knowledge gained of the range and distribution of every important bed in the series.

Though a considerable share of attention had been given during former seasons to the counties south of the Conemaugh and the Ohio, the systematic tracing of their coal measures was still incomplete, more especially throughout parts of Westmoreland and Fayette. I therefore assigned to Dr. Jackson, already familiar with this region, the duty of making a methodical survey of all the unfinished neighborhoods, as far as our time and resources would permit, and in order to expedite the work, he was furnished, in the latter two months of the season, with an adjunct in Mr. Townsend Ward. The same methods of investigation, so successfully applied in other districts of our great western coal field, were adopted here. The principal transverse valleys were carefully searched for natural exposures, and numerous measurements instituted and data collected, for identifying and tracing the individual beds, and for coloring in their outcrops upon the geological map. Though cramped for time, we have succeeded in tracing with all the minuteness desirable, the beautifully symmetrical geology of this productive region.

The portion of this country most minutely examined, is that which lies between the western base of Chesnut ridge and the Monongahela river, and between the Conemaugh and the Virginia line. Some unfinished researches in the valley east of the mountain, were also resumed and completed. The strata brought under investigation in the first and larger tract, commencing below with the bottom of the coal measures, which repose on the western flank of the mountain, and

take in the whole of the series as high as about 200 feet above the Pittsburg coal seam.

This thickness includes several coal seams, lying above the great Pittsburg bed, which occur in the highest hills of the middle or deepest part of the trough which is next west of the mountain. Between the mountain, here called Chesnut Ridge, and the Monongahela river, there are two parallel anticlinal axes which throw these western coal measures into three closely united troughs. The most eastern line of elevation crosses the Conemaugh about two miles west of Blairsville, and ranges to the Virginia line, preserving an average distance of about five miles from the western base of the mountain. In some parts of its course this axis imparts a decided feature to the topography; but elsewhere there is nothing in the contour of the surface merely, which would lead us to look for it. Approaching the southern line of the State the anticlinal arch begins to subside, allowing the lower coal measures, which a few miles further north have been entirely swept away from its summit, to sweep gently over it.

The second axis or arch crosses the Conemaugh about four miles above Saltsburg, and extends parallel to the former, preserving a distance of about five miles, to the west, until it terminates nearly one mile and a-half north of Sewickly creek. Here the arch flattens away, and its eastern dip gives place, at that stream, to a western one, thrown off from the first, and more continuous arch lying east. This second axis is usually indicated by a low belt of hills, the soil of which is much inferior to that in the adjoining troughs. Nearly continuous with this axis, but situated a little to the west of what would be its regular prolongation, there rises further to the southwest, another low anticlinal arch, which elevates the rocks in the vicinity of Brownsville. Between the mountain, therefore, and the first arch or axis west of it, we have a long and narrow trough, of the coal formation, extending the whole distance from the Conemaugh to Virginia; and west of this, or between the first axis and the two other nearly continuous ones, last described, there is another parallel and similar basin, ranging the same distance. West of the Saltsburg and Brownsville axis is the deeper and much broader basin of the counties of Washington, Allegheny and Greene, traversed by a few low undulations not of length and force enough to divide the general one into subordinate troughs, like those in the district east of the Monongahela.

The lower strata of the coal measures, those which underlie the large Pittsburg seam, consist of sandstones, limestones, slates and thin beds of coal. They lean against the western slope of the

Chesnut Ridge, at the base of which the strata next beneath the large coal seam have been swept away along a range of depressions disuniting the outcrop of this main seam from the flank of the mountain.

In this portion of the formation there are four beds of coal, and in two or three localities two other very thin ones, which are not apparently persistent. Only two of the four beds are sufficiently thick to be wrought, the rest measuring from six inches to twenty inches or sometimes two feet. The two available beds vary in thickness from eighteen inches to five feet, the uppermost being commonly the thickest. They are situated low in the series, the inferior one holding a position from twenty to seventy feet above the great coal conglomerate, and the other larger bed lying from 50 to 150 feet above the first. They are generally exposed in the transverse ravines occupied by the streams which cut the flank and base of the mountain, and are associated with the first thick sandstones overlying the conglomerate, in a chain of elevation which blends with the lower slopes of the ridge. They are likewise brought above the drainage of the general plain west of the mountain, in the anticlinal arches, already described, where they are exposed in the little valleys that intersect these axes. They are thus seen on the Conemaugh above Saltsburg and on the Loyalhanna.— On the Sewickly, likewise, both of these beds are exposed, the uppermost being mined for fuel at the saltworks of that stream. These coal beds are again intersected by the valleys of Jacob's creek, of the Youghiogeny and of the Redstone.

The first trough or basin lying west of the mountain, includes the large Pittsburg seam throughout its whole extent. This superb bed occupies the middle of the basin and appears along two lines of outcrop, which range from half a mile to two and a-half miles asunder. In some neighborhoods the bed, as it dips into the middle of the trough, descends to a considerable depth below the lowest water course; while in other places the bottom of the basin which it forms does not reach the water level. A short distance west of the National turnpike this seam arches over the first anticlinal axis, along the central tracts of which it is found high in the hills. In this position it continues into Virginia, where, on the Cheat river, it holds a position probably 200 feet above the level of the stream. The anticlinal arch at this place is very gentle.

This large seam also occupies a portion of the second trough, where it lies in the shape of a long narrow canoe, one end terminating a few miles north of the town of New Alexandria, and the other, three miles southwest of Greensburg. The length of the so called canoe is about

fifteen miles, and its greatest breadth a little less than two miles.—South of the point where the second arch flattens away, the outcrop of the Pittsburgh seam, which lies west of the axis, sweeps eastward round its termination, and takes a corresponding place on the western side of the first and more continuous arch. It continues in this position to the point already mentioned about two miles southwest of the National turnpike, where it folds over this first or eastern arch and blends with that portion of the seam which fills the first trough or basin at the foot of the mountain.

Above this great coal seam there occur several other lesser beds, and an important mass of limestone, which constitutes one of the most persistent of the strata, in the western coal measures. The first coal over the Pittsburgh bed, of any noticeable thickness, is very thin, and in the northern part of the district is sometimes altogether wanting. Advancing southwards to the Sewickly, we find it, however, as thick as four and a-half feet, and composed of very good coal.—Here it is about thirty-five feet above the great seam, and only a short space below the large mass of limestone. Further still to the southwest it somewhat augments in size, and has been wrought at several places. At Evans' mill it is five feet thick and supplies an admirable fuel. Near Uniontown it is separated from the great seam by eighty-five feet of other strata.

The great bed of limestone seems to increase in thickness as it extends to the south-west. Above this limestone, there is a seam of coal which varies in size from eighteen inches to three feet. This is opened at Uniontown, and at several places further to the south-west. Higher still in the series, two other beds occur; but the next seam of importance lies above these again, being confined to the very highest hills in the middle of the first trough. It is opened in several places in Westmoreland and Fayette, and varies from four to six feet in thickness. It was traced and exposed by us at a number of points, where its existence was not before suspected. From the usual high position of this seam in the hills, it is apt to be destitute of a good roof; but wherever it is sufficiently covered, the quality of the coal is excellent. This is the highest valuable coal bed of the district. Besides these now enumerated, several lesser seams, which are only locally important, were examined and their positions in the series ascertained.

The several coal-seams here briefly mentioned, were regularly traced by their outcrops, and their distances and dimensions established at a number of standard localities. Other data were also collected,

by means of which their position, and that of other useful beds, can readily be made known for every part of the district, through a series of transverse and vertical sections, intended to accompany my final report and map.

In the chemical department of the survey, an extensive series of minute and detailed analyses has been performed by my chemical assistant, Dr. Robert E. Rogers. These exhibit the composition and properties of a number of our ores, coals, cements, fluxes, &c., not previously examined, and embrace a variety of interesting results, both local and general. The final comparison of the chemical facts now collected by us, will, it is believed, lead to some general inferences of real economical value and scientific interest. Several trains of chemical research being still in progress, the details and generalizations which they suggest, will be deferred until they can be introduced in a properly matured form in the final report.

From the above sketch of our operations during the past season, it will be seen that, with the exception of a few local tracts unavoidably omitted, through want of time, our researches have included nearly every district of any geological importance, the exploration of which was before unfinished. Should the Legislature authorize my entering at once upon the construction of my final report, I shall probably find opportunity for revising certain neighborhoods, before my final description of their geology goes to press.

Of the Final Report and the Illustrations to accompany it.

The systematic operations in the field having been brought to a successful termination, my principal remaining duty under the law providing for the survey, relates to the preparation of the final report, designed to include all the results, both general and local, of our explorations. It is my intention to enter upon this, which will form the crowning labor of the survey, as soon as I shall have done arranging, in conjunction with my assistants, the large mass of observations made during the past season, a duty which will probably engross me for the remainder of the winter. While I avow my anxiety to urge on this concluding work with all possible diligence, I feel called upon in justice to the interests of the survey, and in fairness to myself, to exhibit to the Legislature the arduous magnitude of the task before me, resulting from the rich abundance of the materials gathered by a large corps, during six active years. Only the few who chance to be

familiar with this species of authorship, can understand what toil and time it requires, to analyse and clearly display all the details and generalizations, essential to so vast a theme. Nor indeed can even they, if they do not take into view the wide extent of the area explored, and its unsurpassed mineral wealth. Not only is Pennsylvania one of the largest regions ever yet brought under systematic geological investigation, but it is for its size by much the richest territory known, in point of available native wealth. Independently of this, it possesses remarkable intricacy of structure. Some conjecture may therefore be formed of the fulness and complexity of the details which it will fall to my task to methodize, condense and elucidate.

That the Legislature may perceive the justice of these remarks, and the propriety of allowing me the time and means necessary to the preparation of my final report, I will here subjoin a brief general sketch of the plan and scope of the work, and its illustrations. In offering this outline, I would most respectfully suggest the expediency of authorizing the engraving of such portions of the illustrations, as may be soonest in readiness, before the meeting of another Legislature. Unless the finished portions of the maps and drawings be allowed to go to press without waiting for the rest, it will be impossible, it seems to me, to accomplish the publication of the whole, before another annual session of the Legislature passes by.

Plan of the Final Report.

The final report, the design of which is to embrace both the general and local results of the survey, ought to comprise, I conceive, two distinct treatises, the one general, the other detailed. The propriety of this will sufficiently appear, when we reflect upon the nature of the observations which belong to a thorough geological examination of a territory so extensive and intricate as Pennsylvania. The whole assemblage of these observations will be found to include on the one hand a vast body of local details, highly instructive to the inhabitants of the districts to which they relate, but not valuable to others; and to lead, on the other hand, to numerous general conclusions and scientific results, mainly interesting to the general reader. The large mass of special details, may be regarded in the light of the scaffolding to the general edifice of our geology; but scaffolding which itself is locally valuable and which it does not become us to reject. To unite in the same pages with the general description, the whole vast body of

particular observations, or the lesser results upon which the larger generalizations depend, would be to load down the work with a tiresome, unintelligible mass of geographical allusions, acceptable neither to the resident nor the distant reader. As, however, this neighborhood geology is often of the utmost *local* value, I propose to embody it in a separate division of the work, in as condensed a shape as will be consistent with the requisite clearness and fulness of detail. By this means, I hope to render it easier for all classes of readers to procure the kind of information they are in pursuit of.

Whilst the general treatise, entire in itself, will make known to the man of science or the general enquirer whatever relates to the composition, ancient origin, and present wonderful and beautiful structure of our formations; and whilst it will show to the capitalist at home and abroad, the position, mode of tracing, and surpassing abundance of our mineral wealth, the other treatise, to which the first will prove a useful key, consisting of the local and economical details, will fulfil a separate object as a work of reference, which can be resorted to for data, for either practical or scientific purposes, and by the owners of the soil, for knowledge of their local resources.

The general treatise will contain a systematic classification and nomenclature of all the formations comprised within the State. It will include a general description of each formation, embracing its prevailing composition, its whole range and distribution, and the changes of thickness and aspect which it undergoes. To this will be added whatever relates to its organic remains and imbedded minerals. The organic remains will deserve to be carefully discussed, for the curious interest which attaches to them as one index to the circumstances under which the strata were originally formed, and for their usefulness in furnishing the best guide which we possess in many cases, to the position of particular mineral layers or beds. The imbedded minerals will likewise be described in all their general relations. Their position in the strata, and the various circumstances connected with their origin, and the manner in which they may be traced, will here be dwelt on. Many curious and important facts connected with the gradual changes which the formations undergo, will also be stated. Among these are the progressive modifications in their thickness, the introduction of some beds and disappearance of others, and whatever relates to the variations in the distribution of their organic remains.

The geological *structure* of every district in the State will be, like-

wise, fully described. Under this head will be exhibited the manner in which many of the strata have been uplifted into more or less inclined positions, and brought to the surface either in long, straight, parallel belts, or in irregular winding ones, or lifted without inclination, and left in horizontal patches. In the same chapters I shall investigate whatever relates to the curious manner in which most of the strata have been formed into more or less closely compressed troughs and arches, synclinal and anticlinal axes, a full account of which alone, can furnish the key to the stratification and resources of at least four-fifths of our territory. While thus describing the axes of elevation and depression, I shall also give an account of the manner in which the rocks have been still more violently deranged by great faults or fractures which intersect them, and shall point to the principles upon which they are to be traced, either along the surface, or below the water level. While thus treating of the various important questions of structure, I shall present my views of the nature of the forces, by whose stupendous agency the ponderous masses that form our mountains have been pleated and folded like a pile of pliant cloth pressed edgewise.

At the same time that both the general and local divisions of the final report will be illustrated by frequent references to the geological maps, the general treatise will be specially accompanied by its own sections, tables, and explanatory drawings.

The other treatise descriptive of the more detailed and local geology, will exhibit the various formations in their minuter features and subdivisions. Following the order pursued in the general treatise, as to the arrangement of the several branches of the subject, it will deviate essentially in the manner of treating the individual formations. In the other part of the work each formation will be independently examined in all its modifications, and traced throughout its entire range; but in this division the arrangement will be a mixed geological and geographical one. The larger geological areas will be subdivided into lesser natural tracts and basins, the limits of which are generally controlled by the valleys and mountain ridges; so that the special geology and mineral resources of each smaller belt of country will be given separately, while all the formations included in it will still be viewed under their proper geological relations.

One principal aim of this division of the work being to present the economical, or more immediately practical results of the survey, I shall here dwell with ample detail upon all observations and deduc-

tions believed to have any useful bearings. In giving a minute account of the rocks of each belt of country, particular mention will be made of whatever relates to the discovery or tracing of any valuable imbedded or associated minerals. By the assistance of the maps and sections, the local range and underground position of all the strata will be fully explained, and a clue or index furnished, wherever we possess it, by which special beds or deposits may easily be recognized. The survey of the State having been mainly undertaken for these economical results, much attention has been devoted to this branch of the investigation. Every useful insulated observation, and especially every available practical rule calculated to assist in detecting or tracing any valuable deposit, whether derived from a comparison of measurements, from the aspect of the strata, from the nature of the fossils, or from the external configuration of the surface, will be specially recorded, and wherever it is necessary explained by resort to diagrams and drawings.

Among the details of an economical character will be included an extensive series of chemical analyses, intended to show the peculiar composition and comparative richness of nearly all the varieties of ores, coals, cements, limestones, and other valuable mineral substances. This portion of the work will contain, it is believed, information of much local interest to the citizens of the State. By pointing out the relative value and quality of particular beds and deposits, in connection with whatever features we find to be distinctive of their composition, a variety of suggestions or rules can be given, corroborated by experiment, for choosing and applying the kinds best suited to their special uses in the arts. Thus, I shall exhibit the results of some chemical researches, not yet completed, relating to variations in the composition of a number of our most widely distributed coal seams, showing the changes which the same beds undergo as they range from place to place, and the characteristic peculiarities of different beds in the same locality. Other similar series of comparative analyses will be presented in relation to the iron ores, cements, and other substances. Many instructive facts, tending to the permanent developement of our mineral wealth, will be thus imparted. But the full value of this very laborious branch of our researches can only be understood when the final report, with its tables and drawings, shall have been published, and the State Cabinet arranged in harmony with the plan and details of the book. Specimens of every valuable vein or layer will be exposed, indicating on their labels their chemical

composition, and, therefore, their useful adaptations. The collection will, at the same time, show with what strata they are associated in nature.

Of the Geological Maps and Sections.

The law authorizing the Geological Survey makes it the duty of the State Geologist to represent, in appropriate colors upon the present State map, all the various formations and mineral strata. This important duty, the proper execution of which is indispensable to the clear elucidation of our geology and mineral resources, I have earnestly endeavored to perform, with all the fidelity compatible with the time allowed, and the very defective character of the basis upon which I have had to work. Very early in the course of our investigations, it became apparant that the imperfections of the State map, amounting to innumerable gross omissions and distortions in the topography, would seriously interfere with the proper delineation of the strata, and preclude entirely the exhibition of many interesting details; thus rendering its usefulness as a guide to the intricate mineral districts, particularly a matter of extreme doubt. We therefore entered upon, and have since persevered in, the gratuitous and arduous duty of compiling principally from our own original measurements and observations, a new map, or rather series of maps, embracing all the mountainous country from the Kittatinny valley to the Allegheny mountain, and from the waters of the Lehigh and Lackawanna to Maryland. This has been a self-imposed task, not specifically enjoined by the law, but undertaken through a conviction of its importance to the practical purposes of the survey. The amount of additional labor required, first, in collecting the data for these maps, and secondly, in constructing them upon a uniform and suitable scale, has been very great. Though far advanced, they will hardly be completed before the month of April, as my assistants and myself are much engaged in recording and systematizing the observations of the past year. The several sheets will be reduced and united into two large maps: one comprising all the region N. E. of the Susquehanna, and the other that part of the mountain chain which lies between that river and Maryland. They are to be upon a uniform scale of two miles to the inch, being a linear expansion of two and a-half times that of the State map. Besides rectifying many of the features of the printed map, which are so inconsistent with the geology, that to follow them in delineating the stratification, would be to picture a number of mere

physical absurdities ; we are enabled, by adopting a large scale, to introduce, in their just and beautiful symmetry, a complicated mass of details, which it would be utterly impossible to crowd into the other cramped and distorted picture of our mountain chain.

Anxious to comply with the letter of the law, I have, at the same time, colored upon the printed map the various formations and mineral belts of the State as accurately and with as much detail as the map itself permitted. A copy of this geological map will be presented with my final report, including such connections as we can introduce from our own original maps, as far as these will go. Notwithstanding the pains taken to delineate the geology of the State upon this map with as few errors and omissions as practicable, such are its inherent defects, that much of the work must go for a mere approximation. Under these circumstances it is for the Legislature to judge whether it would not be wise to authorize the revision and re-engraving of at least the most defective portions of this map, using in its connection the materials embodied in our new geological maps, and the more scattered local data furnished through the numerous public and private railroad and canal surveys, executed of late years and at a great expense, by some of the ablest engineers in the country. The large amount of accurate details in relation to the topography of our State, recorded in the maps and reports of those surveys, many of which were very minute and extensive, ought not to be regarded as so much merely temporary information to be now cast aside. The present moment, when a new edition of the State map is called for by the wants of the geological survey, and by the voice of the public asking for a more accurate guide to our rapidly growing mining districts, seems a fit occasion for placing the map and materials in the hands of some competent geographer to be carefully revised. The cost of making the requisite changes and emendations would not, I am informed, exceed a very moderate sum; and as the present edition is entirely out of print, and the map is waiting, in any event, the action of the Legislature; and as the new demand likely to be created would, in all probability, fully remunerate the State, I would respectfully suggest an early consideration of the subject.

Should the Legislature deem it inexpedient to authorize this correction of the State map, a question presents itself respecting the most suitable form to be given to the general geological map, intended for the illustration of my final report. Some general companion to the report seems indispensable; but whether this should be a geological

map, on the basis of the large one, retaining its present defects, or whether it should be one on a reduced scale, better suited for binding up in a portable form with the other drawings, will rest with the Legislature to decide. As convenience for reference is a matter of first consideration in every map, but especially in one to be so constantly consulted, the reduced and more portable scale, if compatible with accuracy and the requisite degree of minuteness, would seem to claim our choice. If the general map intended to accompany the report were made a mere outline of the topography, but corrected from the data now accessible, and if it were made upon one-half the linear scale of the State map, I should deem it a much more valuable basis for the geology than the present large map in an uncorrected form. Such a reduction could be made, I believe, at a very trivial cost by any skilful professional map maker. I therefore respectfully suggest to the Legislature the expediency of allowing me to dispense with the large State map as an accompaniment to the report, and of permitting me to set on foot and to superintend the construction of the smaller one proposed.

Our own more detailed geological map of the mountain chain of the State will be completed, it is hoped, by the month of May. But it is desirable, in order to give it neatness and clearness, that a regular topographical draftsman be employed to copy it before it goes to the engraver. This would not materially retard its ultimate publication. As my corps of assistants will disperse on the first of April, and as the business of the map maker is in reality foreign from that of the profession of the geologist, and has only now been assumed by us through a strong desire to give our observations an accurate and permanent form, I trust the Legislature will see the propriety of allowing me thus to procure a neat copy of our maps, previous to sending them to the press. Had the appropriation for the incidental expenses of the survey enabled me to embrace this object, I should already have had portions of the maps in the hands of the transcriber. The engraving of the general and more local maps ought, it seems to me, to be expedited as much as practicable, lest the tardy process of finally coloring in the geology may endanger the postponement of the publication beyond the next meeting of the Legislature.

In recommending a reduced and corrected map for the basis of my general geological map of the State, I would not be understood as dissuading the Legislature from a revision of the present large map, the demand for which, were a correct edition published, would, I believe,

be very considerable. Though it need not accompany the geological report, as a portion of its essential illustrations, it might be issued, thus revised, in the form of a separate geological map, according to the demand. The utility of affording our citizens, and the public, a general geological map, minute and full enough to be useful for purposes of reference, either in the office or the field, seems sufficiently obvious, and I cannot but believe that the course I propose would materially augment the income from the State map, in which the Commonwealth has invested a considerable capital.

Sections.

The final report and maps will be accompanied by an extensive series of sections, intended to exhibit whatever is important or remarkable in the stratification of the State. Some of these sections will be general and others local, and they will be of two kinds, horizontal or transverse, and vertical or columnar. The horizontal ones are designed to explain whatever relates to the dip, arching, folding, displacement, and thinning and thickening of the strata as they occur in nature. By exhibiting the edges of all the strata as they would be seen if so many long and deep perpendicular cuts were made across their course, they serve to show not only the places where the several rocks and their imbedded minerals rise to the surface or crop-out, but they likewise indicate the direction which they take underground, and their positions and depths for different neighborhoods. These transverse sections, which generally cross the strata, as nearly at right angles to the direction of their out-crop as practicable, form an indispensable key to the map, which represents the course over the surface of the respective formations, but does not exhibit, as the sections do, the range which they take underground. For the sake of easy reference they are drawn upon the same scale as the maps, or on some convenient multiple of it; but many of the local sections intended to illustrate the more confused and complicated portions of the geology will be on a scale many times that of the maps.

One class of these sections, intended to convey correct preliminary notions of the general physical and geological features of the State, will traverse it entirely from north-west to south-east. Another, and much more numerous set, will extend only the breadth of particular

districts; while a still more extensive series, will cross only special ranges and basins, whose intimate structure, as in the case of some of our coal fields, cannot be adequately explained but by a multiplication of local drawings. Of the latter class, the anthracite coal basins will of themselves require a very considerable series, amounting probably to one hundred, many of them constructed from actual measurements, and all of them compiled from the best data accessible in the time afforded for the investigation. Their object being to display the coal in all the known relations of its outcrop and position below the surface, they have not been made without very arduous and persevering research, conducted during several seasons in the mines and on the surface. For the devoted manner in which those of my assistants, who were entrusted with the details of this part of the survey acquitted themselves of their duty, to the disregard oftentimes of their health, I wish to enter here my earnest testimony. I sincerely hope, therefore, that the Legislature, in authorizing the publication of a final report on the survey, will permit the engraving, in a clear and proper style, of these hard earned details. Should they be withheld, or be imperfectly executed, I shall despair of rendering many parts of our perplexingly intricate, though abundant coal fields, intelligible to the public.

The vertical or columnar sections, are intended to exhibit in detail, the order of succession and actual thickness of the strata for different districts and neighborhoods. A few of these will be merely general, representing the average relations of the rocks as they occur in regions of considerable area. By far the largest number will be locally illustrative, and will comprise the results of an extensive series of critical examinations and measurements, made at various places, with a view to ascertain and exhibit the precise positions, dimensions and composition, of the several lesser subdivisions of the strata, including even the smallest recognizable mineral beds. By exhibiting a full series of such vertical sections, I shall be enabled to give a much more thorough insight into the local stratification, than I could possibly impart by unassisted description. They will be so drawn, as to convey to the eye at once the whole succession of beds at each particular locality. By comparing together those which relate to the same formation, or the same subdivision of a formation, it will readily be seen what changes each member undergoes, and to what extent given beds or deposits alter their relative thicknesses and distances, or disappear from the series. These sections will also make it apparent at what

depths the same beds occur at different places, while they will approximately indicate the position of the more persistent layers for intermediate places, thus serving the purpose of a valuable practical guide to those who may wish to explore any particular neighborhood.

Being especially adapted to exhibit the details of the stratification, in the more gently dipping or horizontal positions of the coal formation, I have introduced them extensively, to illustrate the minute features of the great bituminous coal region north-west of the Allegheny mountain. The strata of that interesting portion of our State, though divided more or less into a succession of parallel troughs or basins, by a series of anticlinal axes, belong originally to one continuous formation. The portions now insulated from each other, by upheaval and denudation, though often separated by a belt of wholly different strata, or even by a bold mountain ridge, are characterized by features of very close identity. It is therefore obvious, that carefully measured vertical sections of the beds may serve as so many more or less correct indexes to the strata of other localities, and even of different basins. This gives them a wide application as a key to the geology. Perhaps no other known coal region, except this wide one of western Pennsylvania and Virginia, admits of so extensive and intelligible a comparison of its stratification, or is so easily illustrated by this neat and simple means of vertical sections. I have, therefore, caused our western strata to be measured at a number of localities, embracing all the basins from the Allegheny mountain, northward and westward throughout the formation, selecting for the points of examination, the best exposures in the hills which border the valleys of the larger streams.

The State Cabinets.

The Legislature at its last session required "the preparation of three complete collections or cabinets of geological and mineralogical specimens for the use of the State," to be severally deposited at Harrisburg, Philadelphia and Pittsburg. The ample collection made, of our rocks, minerals and fossils, can in due time be separated into the three series required, without materially injuring the entireness of either set, as the precaution was early taken to collect, in the greater number of instances, three specimens of each variety. But I regret to state, that ever since the passage of the act imposing this arduous task, my assistants and myself have been so incessantly engrossed, first with

duties in the field, and subsequently, with the indispensable labor of preparing our manuscripts, maps and sections, that little has been accomplished towards the arrangement of the three cabinets, beyond what had been previously effected.

To render these cabinets as useful as possible to the public, the specimens should be arranged, I conceive, in an order as strictly conformable as possible with the combined geographical and geological distribution of the subjects in the detailed portion of my final report. In other words, the arrangement of the cases and shelves ought to run parallel with that of the chapters and sections of the book. But to effect this without innumerable mistakes and much waste of time, implies that I shall have made some considerable progress with my final report. As it is, nevertheless, highly desirable that the arrangement of the collections should be completed by the time the final report is through the press, and as the business of setting up the cabinets might go on while I am still at my pen, and much time be thereby ultimately gained, I hope that the Legislature will deem it expedient to take measures for enabling me to proceed with this portion of my task. The first of April next witnesses the dispersion of my corps, the appropriation for our salaries then ceasing. Should the Legislature resolve to give to the public the results of the survey without delay, it seems desirable that some action be taken on the subject of preparing a suitable reception for the three general cabinets.

I have thus, in the foregoing pages, endeavored to exhibit to the Legislature the present posture of the survey, and the best course of action I can suggest for bringing our results and materials speedily and in a useful shape before the public. What I have concisely said in relation to the scope and plan of my forthcoming work, will suffice to show the extent and arduous nature of the task which yet remains to be performed, and will, I trust, procure me the time indispensable for its proper completion. Deprived of the services of my assistants, it will fall to my duty to produce, single handed, a thorough digest of the observations and gatherings of six years, made by a large and fully organized corps.

That the due performance of the duties yet before me will demand at least one year, will be obvious on a brief recapitulation of what remains to be accomplished:—

1st. The composition of the final report, which is to comprise both a general and detailed description of our geology and mineral resources.

2d. The construction and coloring of the general and local geological maps, and a very extensive series of transverse and vertical sections.

3d. The examination of the organic remains, and the preparation of the requisite descriptions and drawings of the characteristic species.

4th. The arrangement and labelling of three extensive collections of specimens, a work, in itself, of considerable time and labor.

5th. Add to these duties that of superintending the press.

Impressed with the serious magnitude of these labors, I have deemed it only my duty to make known the indispensable necessity of time for their performance. The construction of an elaborate scientific work is not like that of a material edifice, the building of which may occupy many laborers to the last. Here the architect must often be himself the sole workman in all that relates to the final arrangement of his materials. In various collateral details he may receive very essential help, and hence I shall feel the burden of my duties seriously augmented by the dispersion of my assistants.

In view of all these considerations, and earnestly anxious to complete my task as early as its faithful performance will allow, I have here ventured upon several suggestions which, if acted on, will tend materially to hasten the completion of the work. Some of these I beg leave, in conclusion, to re-state.

First.—Connected with the early publication of the final report, I would recommend the importance of an appropriation at this time for engraving the maps and sections.

Secondly.—I would suggest that authority be given for procuring out of this appropriation the reduction of the State map to one-half the linear scale of the present plate, the new map to embody the corrections supplied by the geological, and other surveys. Also, that this map be made the basis of the general geological map of the State, and that a part of the fund for publication be applied to procuring a neat and clear copy of the geological and topographical maps of the mountain chain of the State, and for getting them engraved as soon as practicable. It is further recommended that a similar provision be made for a revision and new edition of the State map, to embody all the correct data accessible.

Thirdly.—In regard to the State Cabinets, it is suggested that some steps be now taken for the reception and display of the three large collections of specimens to be severally deposited in Harrisburg, Philadelphia, and Pittsburg.

All which is respectfully submitted.

HENRY D. ROGERS.

PHILADELPHIA, *February 1, 1842.*







